FETAL AND INFANT MORTALITY AND CONGENITAL HYPOTHYROIDISM AROUND TMI*

George K. Tokuhata, Dr.P.H., Ph.D.**
Edward Digon, M.P.H.***

Director**
Division of Epidemiological Research

Chief***
Special Studies Section
Division of Epidemiological Research

Pennsylvania Department of Health
P.O. Box 90
Harrisburg, PA 17108

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**Professor of Epidemiology and Biostatistics, University of Pittsburgh Graduate School of Public Health (adjunct); Associate Professor of Community and Family Medicine, Temple University College of Medicine (adjunct).

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The Three Mile Island nuclear accident of March 28, 1979 has resulted in marked social unrest locally, nationally and world-wide, particularly with respect to the health and safety of nuclear energy. Subsequent to the accident the Pennsylvania Department of Health initiated a comprehensive evaluation of possible health impacts of the accident. Specific studies developed during this critical period reflect the existing epidemiological knowledge regarding biological effect of low level ionizing radiation and of severe emotional stress.

One of the most important studies developed was to determine if the TMI nuclear accident has had any measurable effects upon pregnancy outcome and infant health in the vicinity of the damaged nuclear reactor. It is known that the embryo and the fetus are highly sensitive to adverse environmental insults, which can cause mutations and/or congenital malformations and affect postnatal growth, development, and morbidity.

For the purpose of the present study, we considered a 10-mile radius of the Three Mile Island, wherein approximately 4,000 infants are born annually (Table 1). Both levels of radiation exposure and psychological distress within the 10-mile radius were higher than those beyond the 10-mile radius. The available mortality data were analyzed by calendar quarters, as well as annually for each of the three consecutive years, 1977, 1978, and 1979, for the entire 10-mile area, including Harrisburg, the 10-mile area excluding Harrisburg, and Harrisburg independently. For cross-sectional comparison, corresponding mortality data for the State of Pennsylvania as a whole, were evaluated for the same historical time frames.

As indicated in Table 2, the infant mortality rate was not significantly different between the 10-mile area with or without Harrisburg and the State

of Pennsylvania for any of the three years under consideration. The higher death rate indicated for Harrisburg separately is a reflection of the fact that approximately one-half of the infants born in the city were nonwhite.

The infant mortality rate within the 10-mile radius, including Harrisburg, was already considerably high (19.3 per 1,000 live births) during the first quarter of 1979 prior to the TMI accident. The rate remained at the same level during the second quarter of 1979 immediately following the accident, but declined substantially during the third (12.7) and fourth (13.4) quarters. This temporal pattern of change in the rate is consistent with the view that the TMI accident has had no measurable impact upon infant mortality. Otherwise, the infant mortality rate would have increased steadily (or, at least, would have remained high as a result of interaction between seasonal downward trend and TMI-related upward trend), particularly during the third and early fourth quarters. Fetal sensitivity to radiation and maternal distress is much greater when exposure occurs in the earlier period of gestation and this would have been reflected in a rising mortality rate in the period nine to ten months following the accident.

Within the 10-mile radius, the 1979 infant mortality rate (16.1) was not significantly different from the 1977 rate (12.5). The 1978 infant mortality rate (10.8) was somewhat atypical and unusually low, particularly for areas outside of Harrisburg (8.4). Because of this, the 1978 rate should not be used as a normal base for comparison.

Having considered both cross-sectional and temporal analyses of the available vital statistics data compiled by the State Health Department, we found no evidence that the TMI nuclear accident has had any significant impact upon infant mortality. Minor statistical variations, as observed in the 10-mile

radius, are considered to be a typical random phenomenon in a relatively small population with no particular epidemiologic significance.

The pattern of fetal mortality rate in the vicinity of the Three Mile Island was somewhat different, but there is no indication that the TMI accident was related to its quarterly variations (Table 3). The level of fetal mortality within the 10-mile communities was, in fact, considerably lower than that for the State as a whole.

One of the important radioactive releases during the TMI nuclear accident was that of I^{131}. Since it is known that radioactive iodine can cause hypothyroidism and that I^{131} can be taken up by pregnant women and absorbed by the fetal thyroid gland through the placenta after the tenth week of gestation, we decided to examine the incidence of congenital hypothyroidism among newborn infants. The fetal thyroid gland is much more sensitive to radioactive iodine than is the mother's thyroid gland; i.e., a relatively small dose to the mother can be a relatively large dose to the fetus.

In a normal population, the incidence of congenital hypothyroidism is approximately one in 4,500 to 5,000 infants. There are several different diagnostic classes of this condition: namely, genetic type (mostly autosomal recessive, resulting from dyshormonogenesis, i.e., lack of enzyme to synthesize thyroxine); ectopic type (dysgenesis, i.e., incomplete maturation and/or displacement of the thyroid glands); agenesis (without thyroid gland); and other types.

During the March 28, 1979-March 27, 1980 period only one case of congenital hypothyroidism was identified within the 10-mile communities, where approximately 4,000 infants were born. This incidence rate is well within a normal range of expectation.

An apparent clustering of seven cases reported in Lancaster County (mostly beyond a 10-mile radius) during 1979 was subjected to a special in-depth analysis. Of the seven cases, one was reported prior to the TMI accident. One with severe multiple CNS anomalies was born three months after the accident; this case is unlikely to be associated with TMI because of the late gestation period of the fetus when the nuclear accident occurred and also of coexisting developmental anomalies which are unlikely to be associated with radiation. One case was of dysgenesis representing one of discordant Amish twins, thus, non-supportive of the etiology secondary to radiation exposure. Another case of dysgenesis in whom the thyroid glands were displaced from the normal position. One case of dyshormonogenesis from an Amish family where the condition (lack of enzyme to synthesize thyroxin) was inherited from the parents.

Having completed detailed diagnostic analysis and epidemiologic assessment of the cases reported in Lancaster County during 1979, we concluded that cases of congenital hypothyroidism were not related to the TMI nuclear accident. The Lancaster County is atypical in that a considerable proportion of the county population includes Amish families where consanguinity is not uncommon and the incidence of certain genetic diseases and related conditions is higher than other populations.

The Statewide incidence of congenital hypothyroidism for 1979 was one per 4,600 live births, which is well within a normal range of expectation. The Statewide incidence for 1980 was one per 4,427 live births, which is also within a normal range.

Apart from the incidence analysis presented above, there is also an important consideration with respect to radiation in relation to congenital hypothyroidism.

First, from March 28 through December 31, 1979, no single case of congenital hypothyroidism was reported in Dauphin, Cumberland, Perry, Northumberland, Juniata, Snyder, Mifflin, and Union Counties, the areas downwind(N, NW, NNW) from the Three Mile Island during the first 48 hours of the accident, when probably the largest amount of radioactive releases took place.

Second, the maximum combined (inhalation and ingestion) human thyroid dose of radioactive iodine in the vicinity of the TMI following the March 28, 1979 accident through April 1979 is estimated to be 7.5 mrad (Editorial: Annals of Internal Medicine, Vol. 91, No. 3, September 1979). At least 1,000 times greater thyroid doses (i.e., 7.5 rads) would be required to have significant acute damages to the thyroid gland; however, even at this dose level, many of the damaged cells may be repaired. Based on the experiences of the Marshallese exposed to fresh radioactive fallout, it is considered likely that as much as 50 to 100 rads fetal thyroid doses would be necessary to cause irreversible tissue damages, such as congenital hypothyroidism and/or thyroid cancer. Acknowledging the fact that the fetal thyroid is much more sensitive to radioiodine than is the maternal thyroid (a conservative upper bound estimate is that the thyroid dose to a fetus may be as high as ten times the maternal thyroid dose), the maximum likely fetal thyroid dose (approximately 75 mrad) and the maximum possible thyroid dose of 190 to 200 mrad in the vicinity of the damaged nuclear plant are still far too small to have caused congenital hypothyroidism.

In an epidemiological investigation of possible "clustering" of a disease or morbid condition, it is important to recognize the technical difficulty and methodological limitations associated with such investigation. It is the overall consistent pattern of observation that provides useful basis for conclusion, rather than a single isolated change or difference, which in most cases occurs

without substantive epidemiologic significance. This is particularly true when relatively small populations are being studied. One may or may not find a "statistically significant" change, difference, or clustering in morbid rates in an area depending upon how such population is delineated geographically and/or temporally. It is equally important that investigators carefully examine the observed relationships and determine if such relationships are consistent with the known biological theory or orientation, which is based on previous studies and experiences. Our conclusions regarding infant mortality and congenital hypothyroidism around the Three Mile Island nuclear plant have been based on both the overall pattern of epidemiologic observations and in reference to existing scientic knowledge.

TABLE 1: RESIDENT LIVE BIRTHS BY QUARTER: PENNSYLVANIA AND TEN MILE TMI AREA COMMUNITIES, 1977-1979

Year/Quarter	Pennsylvania	TMI Ten Mile Area		
		Total	Harrisburg City	Excluding Hbg. City
1977	(153,415)	(3,750)	(1,001)	(2,749)
Jan.-March	36,911	886	242	644
April-June	38,414	937	248	689
July-Sept.	40,181	977	274	703
Oct.-Dec.	37,909	950	237	713
1978	(151,438)	(3,803)	(1,057)	(2,746)
Jan.-March	37,084	926	261	665
April-June	36,339	922	262	660
July-Sept.	39,932	1,029	302	727
Oct.-Dec.	38,083	926	232	694
1979	(157,533)	(3,905)	(1,185)	(2,720)
Jan.-March	38,326	932	296	636
April-June	38,351	983	303	680
July-Sept.	41,933	1,023	302	721
Oct.-Dec.	38,923	967	284	683

TABLE 2: RESIDENT INFANT DEATHS, NUMBER AND RATE, BY QUARTER: PENNSYLVANIA AND TEN MILE TMI AREA COMMUNITIES, 1977-1979

Year/Quarter	Number of Deaths				Death Rate Per 1,000 Live Births			
		Ten Mile TMI Area				Ten Mile TMI Area		
	Pa.	Total	Harrisburg City	Excluding Hbg. City	Pa.	Total	Harrisburg City	Excluding Hbg. City
				Infant Deaths				
1977	(2,137)	(47)	(15)	(32)	(13.9)	(12.5)	(15.0)	(11.6)
Jan.-March	544	13	6	7	14.7	14.7	24.8	10.9
April-June	554	11	2	9	14.4	11.7	8.1	13.1
July-Sept.	520	9	3	6	12.9	9.2	10.9	8.5
Oct.-Dec.	519	14	4	10	13.7	14.7	16.9	14.0
1978	(2,031)	(41)	(18)	(23)	(13.4)	(10.8)	(17.0)	(8.4)
Jan.-March	530	13	8	5	14.3	14.0	30.7	7.5
April-June	509	9	3	6	14.0	9.8	11.5	9.1
July-Sept.	473	5	1	4	11.8	4.9	3.3	5.5
Oct.-Dec.	519	14	6	8	13.6	15.1	25.9	11.5
1979	(2,118)*	(63)	(31)	(32)	(13.4)	(16.1)	(26.2)	(11.8)
Jan.-March	511	18	10	8	13.3	19.3	33.8	12.6
April-June	537	19	9	10	14.0	19.3	29.7	14.7
July-Sept.	507	13	3	10	12.1	12.7	9.9	13.9
Oct.-Dec.	562	13	9	4	14.4	13.4	31.7	5.9

*Includes one death, month of occurrence, unknown.

TABLE 3: RESIDENT FETAL DEATHS (TOTAL), NUMBER AND RATE, BY QUARTER: PENNSYLVANIA AND TEN MILE TMI AREA COMMUNITIES, 1977-1979

Year/Quarter	Number of Deaths				Death Rate Per 1,000 Deliveries*			
		Ten Mile TMI Area				Ten Mile TMI Area		
	Pa.	Total	Harrisburg City	Excluding Hbg. City	Pa.	Total	Harrisburg City	Excluding Hbg. City
				Fetal Deaths (Total)				
1977	(4,058)	(80)	(45)	(35)	(25.8)	(20.9)	(43.0)	(12.6)
Jan.-March	1,062	16	10	6	28.0	17.7	39.7	9.2
April-June	992	18	9	9	25.2	18.8	35.0	12.9
July-Sept.	1,026	23	12	11	24.9	23.0	49.0	15.4
Oct.-Dec.	978	23	14	9	25.1	23.6	55.8	12.5
1978	(4,034)	(77)	(38)	(39)	(25.9)	(19.8)	(34.7)	(14.0)
Jan.-March	1,003	15	5	10	26.3	15.9	18.8	14.8
April-June	1,047	21	12	9	28.0	22.3	43.8	13.5
July-Sept.	1,001	20	10	10	24.5	19.1	32.1	13.6
Oct.-Dec.	983	21	11	10	25.2	22.2	45.3	14.2
1979	(3,608)	(67)	(37)	(30)	(22.4)	(16.9)	(30.3)	(10.9)
Jan.-March	938	24	13	11	23.9	25.1	42.1	17.0
April-June	916	12	6	6	23.3	12.1	19.4	8.7
July-Sept.	937	16	10	6	21.9	15.4	32.1	8.3
Oct.-Dec.	817	15	8	7	20.6	15.3	27.4	10.1

*Deliveries: Live births and fetal deaths (including abortions).